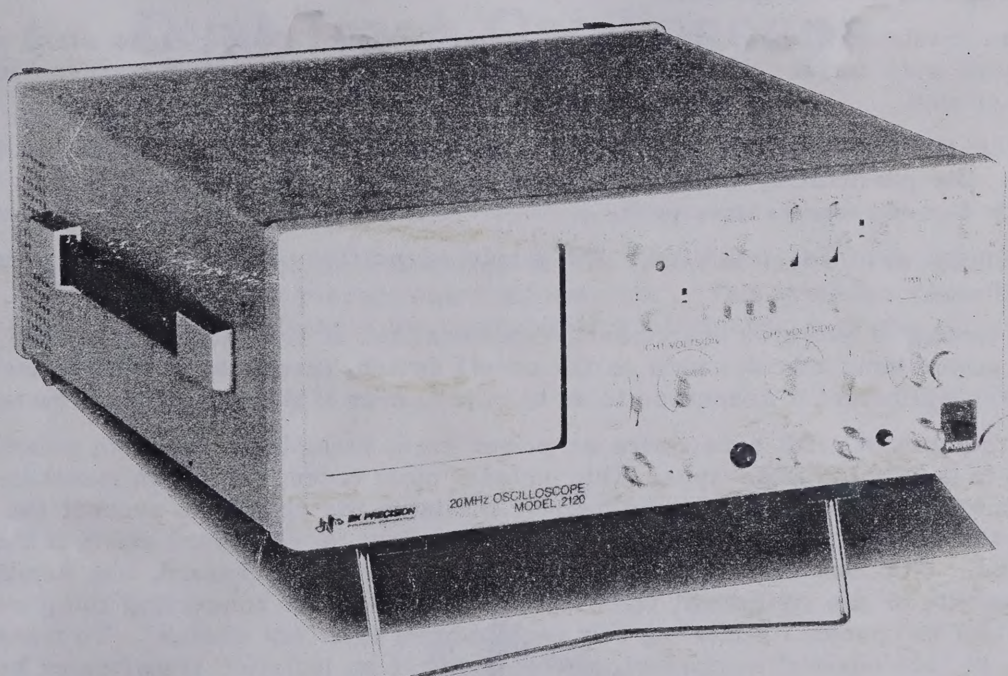
INSTRUCTION MANUAL

BK PRECISION
DYNASCAN CORPORATION

MODEL 2120

20 MHz DUAL-TRACE OSCILLOSCOPE



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TEST INSTRUMENT SAFETY

WARNING

Normal use of test equipment exposes you to a certain amount of danger from electrical shock because testing must often be performed where exposed high voltage is present. An electrical shock causing 10 milliamps of current to pass through the heart will stop most human heartbeats. Voltage as low as 35 volts dc or ac rms should be considered dangerous and hazardous since it can produce a lethal current under certain conditions. Higher voltage poses an even greater threat because such voltage can more easily produce a lethal current. Your normal work habits should include all accepted practices that will prevent contact with exposed high voltage, and that will steer current away from your heart in case of accidental contact with a high voltage. You will significantly reduce the risk factor if you know and observe the following safety precautions:

1. Don't expose high voltage needlessly in the equipment under test. Remove housings and covers only when necessary. Turn off equipment while making test connections in high-voltage circuits. Discharge high-voltage capacitors after removing power.

2. If possible, familiarize yourself with the equipment being tested and the location of its high voltage points. However, remember that high voltage may appear at unexpected points in defective equipment.

3. Use an insulated floor material or a large, insulated floor mat to stand on, and an insulated work surface on which to place equipment; make certain such surfaces are not damp or wet.

4. Use the time-proven "one hand in the pocket" technique while handling an instrument probe. Be particularly careful to avoid contacting a nearby metal object that could provide a good ground return path.

5. When using a probe, touch only the insulated portion. Never touch the exposed tip portion.

6. When testing ac powered equipment, remember that ac line voltage is usually present on some power input circuits such as the on-off switch, fuses, power transformer, etc. any time the equipment is connected to an ac outlet, even if the equipment is turned off.

7. Some equipment with a two-wire ac power cord, including some with polarized power plugs, is the "hot chassis" type. This includes most recent television receivers and audio equipment. A plastic or wooden cabinet insulates the chassis to protect the customer. When the cabinet is removed for servicing, a serious shock hazard exists if the chassis is touched. Not only does this present a dangerous shock hazard, but damage to test instruments or the equipment under test may result from connecting the ground lead of most test instruments (including this oscilloscope) to a "hot chassis". To make measurements in "hot chassis" equipment, always connect an isolation transformer between the ac outlet and the equipment under test. The **B & K-Precision** Model TR-110 or 1604 Isolation Transformer, or Model 1653 or 1655 AC Power Supply is suitable for most applications. To be on the safe side, treat all two-wire ac powered equipment as "hot chassis" unless you are sure it has an isolated chassis or an earth ground chassis.

8. Never work alone. Someone should be nearby to render aid if necessary. Training in CPR (cardio-pulmonary resuscitation) first aid is highly recommended.

Instruction Manual

for

BK PRECISION
DYNASCAN CORPORATION

Model 2120

20 MHz

Dual-Trace Oscilloscope

This symbol on oscilloscope means "refer to instruction manual for further precautionary information". This symbol appears in the manual where the corresponding information is given.

BK PRECISION
DYNASCAN CORPORATION

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FEATURES

DUAL TRACE FEATURES

Dual Trace
Model 2120 has two vertical input channels for displaying two waveforms simultaneously. Selectable single trace (either CH 1 or CH 2) or dual trace. Alternate or chop sweep selectable at all sweep rates.

Sum and Difference Capability
Permits algebraic addition or subtraction of channel 1 and channel 2 waveforms, displayed as a single trace. Useful for differential voltage and distortion measurements.

CRT FEATURES

Rectangular CRT
Rectangular CRT with large 8 x 10 centimeter viewing area.

Convenience
Trace rotation electrically adjustable from front panel. 0%, 10%, 90%, and 100% markers for rise time measurements.

VERTICAL FEATURES

High Sensitivity
5 mV/div sensitivity for full bandwidth. Gain increase with **VARIABLE** control increases sensitivity to a minimum of 2 mV/div (uncalibrated).

Calibrated Voltage Measurements
Accurate voltage measurements (±3%) on 10 calibrated ranges from 5 mV/div to 5 V/div. Vertical gain fully adjustable between calibrated ranges.

SWEEP FEATURES

Calibrated Time Measurements
Accurate (±3%) time measurements. Model 2120 has 18 calibrated ranges from 0.2 s/div to 0.5 μs/div. Sweep time is fully adjustable between calibrated ranges.

X10 Sweep Magnification
Allows closer examination of waveforms, increases maximum sweep rate to 50 ns/div.

TRIGGERING FEATURES

Two Trigger Modes
Selectable normal (triggered) or automatic sweep modes.

Triggered Sweep
Sweep remains at rest unless adequate trigger signal is applied. Fully adjustable trigger level and (+) or (-) slope.

AUTO Sweep
Selectable AUTO sweep provides sweep without trigger input, automatically reverts to triggered sweep operation when adequate trigger is applied.

Five Trigger Sources
Five trigger source selections, including CH 1, CH 2, ALT, EXT, and LINE. In ALT mode, each waveform becomes its own trigger (alternate triggering).

Three Trigger Coupling Choices
Selectable AC, TV H (Line), or TV V (Frame) trigger coupling.

Video Sync
Frame (TV V) or Line (TV H) triggering selectable for observing composite video waveforms.

OTHER FEATURES

X-Y Operation
Channel 2 can be applied as horizontal deflection (X-axis) while channel 1 provides vertical deflection (Y-axis).

Built-In Probe Adjust Square Wave
A 0.2 V p-p, 1 kHz square wave generator permits probe compensation adjustment.

Channel 1 Output

A buffered 50Ω output of the channel 1 signal is available at the rear panel for driving a frequency counter or other instruments. The output is 50 mV/div into 50Ω.

Supplied With Two Probes

Low Boy Configuration

Low profile housing saves bench space and allows oscilloscope to be carried like a briefcase.

SPECIFICATIONS

CRT:

Type:
Rectangular with internal graticule.

Display Area:
8 x 10 div(1 div = 1 cm).

Accelerating Voltage:
2 kV.

Phosphor:
P31.

VERTICAL AMPLIFIERS (CH 1 and CH 2)

Sensitivity:
5 mV/div to 5 V/div in 1-2-5 sequence, 10 steps. Vernier control provides fully adjustable gain between steps and increases maximum sensitivity to 1 mV/div (at reduced bandwidth).

Accuracy:
±3%.

Input Resistance:
1 MΩ ±2%.

Input Capacitance:
35 pF ±5 pF.

Frequency Response:
5 mV to 5 V/div (CAL):
DC to 20 MHz (-3 dB).
1 mV/div (uncalibrated):
DC to 10 MHz (-3 dB).

Rise Time:
Approximately 17.5 ns.

Operating Modes:

CH 1:	CH 1, single trace.
CH 2:	CH 2, single trace.
ALT:	dual trace, alternating.
CHOP:	dual trace, chopped.
ADD:	algebraic sum of CH 1 + CH 2.

Polarity Reversal:
CH 1 only.

Maximum Input Voltage:
400 V dc + ac peak.

Maximum Undistorted Amplitude:
DC-to-20 MHz: 4 divisions.
DC-to-10 MHz: 8 divisions.

HORIZONTAL AMPLIFIER
(Input through channel 2 input)

X-Y mode: switch selectable using X-Y switch.
CH 1: Y axis.
CH 2: X axis.

Sensitivity:
Same as vertical channel 2.

Accuracy:
Y-Axis: ±3%.
X-Axis: ±6%.

Input Impedance:
Same as vertical channel 2.

Frequency Response:
DC to 2 MHz typical (-3 dB) (to 6 divisions horizontal deflection).

X-Y Phase Difference:
Approximately 3^{o} at 50 kHz.

Maximum Input Voltage:
Same as vertical channel 2.

SWEEP SYSTEM

Sweep Speed:
0.5 µs/div to 0.2 s/div in 1-2-5 sequence, 18 steps. Vernier control provides fully adjustable sweep time between steps.

Accuracy:
±3%.

Sweep Magnification:
10X, ±6%.

TRIGGERING

Trigger Modes:
AUTO (free run) or NORM.

Trigger Source:
CH 1, CH 2, ALT, EXT, LINE.

Maximum External Trigger Voltage:
200 V dc + ac peak.

Trigger Coupling:

AC	30 Hz to 30 MHz.
TV H	Used for triggering from horizontal sync pulses.
TV V	Used for triggering from vertical sync pulses.

Trigger Sensitivity:

COUPLING	BANDWIDTH	INT	EXT
AC	30 Hz - 30 MHz	.5 div	500 mV
TV V	10 Hz - 1.5 kHz	.5 div	500 mV
TV H	3 kHz - 30 MHz	.5 div	500 mV

OTHER SPECIFICATIONS

Calibrating Voltage:
1 kHz (±10%) Positive Square Wave, 0.2 V p-p (±2%).

CH 1 Output (on rear panel):

Output Voltage:
50 mV/div (into 50-ohm load).

Output Impedance:
Approximately 50 ohms.

Frequency Response:
20 Hz to 10 MHz, -3 dB, into 50 Ω.
20 Hz to 20 MHz, -6 dB, into 1 MΩ.

Trace Rotation:
Electrical, front panel adjustable.

Power Requirements:
115 V/230 V ±10%, 50/60 Hz, approximately 35 W.

Dimensions:
320 x 130 x 361 mm (12.6 x 5.1 x 14.2").

Weight:
Approximately 6.8 kg (15 lbs).

SUPPLIED ACCESSORIES:
Two Probes.
Schematic Diagram and Parts List.
AC Power Cord.

OPTIONAL ACCESSORIES:
10:1 Probe, Model PR-46.
100:1 Probe, Model PR-100.

CONTROLS AND INDICATORS

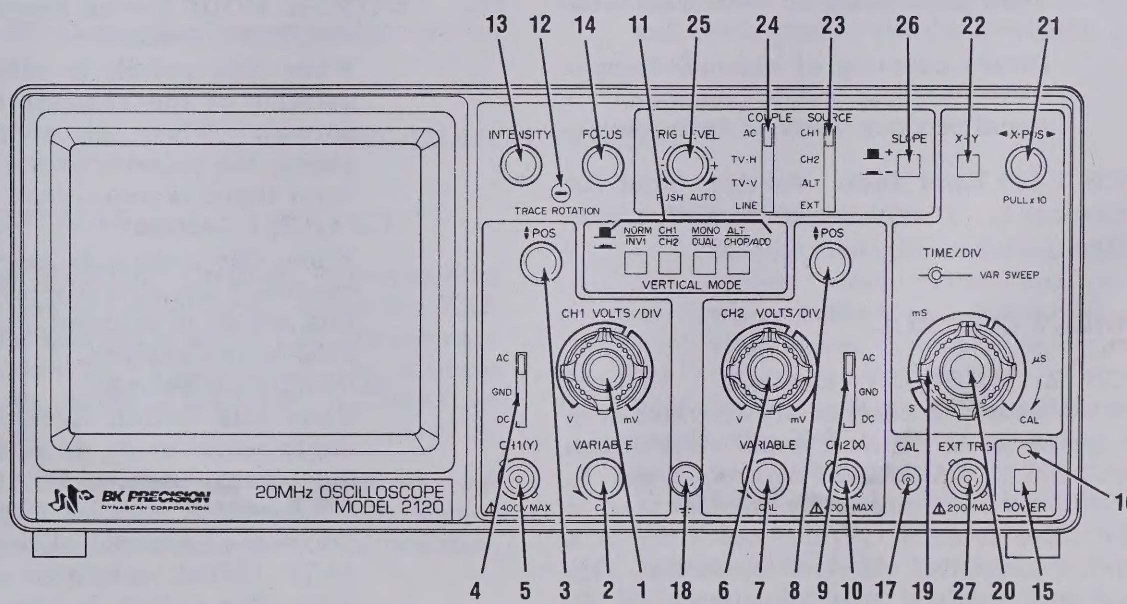


Fig. 1. Front Panel Controls And Indicators.

VERTICAL CONTROLS

CHANNEL 1 CONTROLS

1. **CH 1 VOLTS/DIV Control.** Vertical attenuator for channel 1. Provides step adjustment of vertical sensitivity. When channel 1 **VARIABLE** control is set to **CAL,** vertical sensitivity is calibrated in 10 steps from 5 mV/div to 5 V/div in a 1-2-5 sequence. When the X-Y mode of operation is selected, this control provides step adjustment of Y-axis sensitivity.

2. **VARIABLE Control.** Rotation provides vernier adjustment of channel 1 vertical sensitivity. In the fully counterclockwise (**CAL**) position, the vertical attenuator is calibrated. Clockwise rotation increases gain sensitivity. In X-Y operation, this control becomes the vernier Y-axis sensitivity control.

3. **⬍ POSition Control.** Rotation adjusts vertical position of channel 1 trace. In X-Y operation, rotation adjusts vertical position of display.

4. **AC-GND-DC Switch.** Three-position lever switch which operates as follows:

AC:
Channel 1 input signal is capacitively coupled; dc component is blocked.

GND:
Opens signal path and grounds input to vertical amplifier. This provides a zero-volt base line, the position of which can be used as a reference when performing dc measurements.

DC:
Direct coupling of channel 1 input signal; both ac and dc component of signal produce vertical deflection.

5. **CH 1 (Y) Input Jack.** Vertical input for channel 1. Y axis input for X-Y operation.

CHANNEL 2 CONTROLS

6. **CH 2 VOLTS/DIV Control.** Vertical attenuator for channel 2. Provides step adjustment of vertical sensitivity. When channel 2 **VARIABLE** control is set to **CAL**, vertical sensitivity is calibrated in 10 steps from 5 mV/div to 5 V/div in a 1-2-5 sequence. In X-Y operation, this control provides step adjustment of X-axis sensitivity.

7. **VARIABLE Control.** Rotation provides vernier adjustment of channel 2 vertical sensitivity. In the fully counterclockwise (**CAL**) position, the attenuator is calibrated. Clockwise rotation increases gain sensitivity. In X-Y operation this control becomes the vernier X-axis sensitivity control.

8. **▲▼ POSition Control.** Rotation adjusts vertical position of channel 2 trace.

9. **AC-GND-DC Switch.** Three-position lever switch which operates as follows:

AC:
Channel 2 input signal is capacitively coupled; dc component is blocked.

GND:
Opens signal path and grounds input to vertical amplifier. This provides a zero-volt base line, the position of which can be used as a reference when performing dc measurements.

DC:
Direct coupling of channel 2 input signal; both ac and dc component of signal produce vertical deflection.

10. **CH 2 (X) Input Jack.** Vertical input for channel 2. X-axis input in X-Y operation.

11. **VERTICAL MODE Switch Assembly.**

NORM/INV 1 Switch:
When this switch is released, the polarity of the channel 1 signal is normal. When this switch is engaged, the polarity of the channel 1 input signal is reversed.

CH 1/CH 2 Switch:
When this switch is released, the channel 1 signal is displayed. When this switch is engaged, the channel 2 signal is displayed.

MONO/DUAL Switch:
When this switch is released, the single-trace mode is selected and the signal selected by the **CH 1/ CH 2** switch will be displayed (or the sum of channels 1 and 2 if the **ALT/ CHOP** switch is engaged). When this switch is engaged, both the channel 1 and channel 2 signals will be displayed.

ALT/CHOP/ADD Switch:
When this switch is released in the dual-trace mode, the channel 1 and channel 2 inputs are alternately displayed (normally used at faster sweep speeds). When this switch is engaged in the dual-trace mode, the channel 1 and channel 2 inputs are chopped and displayed simultaneously (normally used at slower sweep speeds). When this switch is released in the single-trace mode, only the signal selected by the **CH 1/CH 2** switch will be displayed. When this switch is engaged in the single-trace mode, the input from channel 1 and channel 2 are summed and displayed as a single signal. When the **INV 1** switch is also engaged, the input from channel 1 is subtracted from channel 2 and the difference is displayed as a single signal.

12. **TRACE ROTATION Control.** Use a screwdriver to adjust the trace to a horizontal position.

13. **INTENSITY Control.** Adjusts brightness of trace.

14. **FOCUS Control.** Adjusts trace focus.

15. **POWER Control.** Turns oscilloscope on and off.

16. **POWER Indicator.** Lights when is oscilloscope is on.

17. **CAL Terminal.** This terminal provides a 1 kHz, 0.2-volt peak-to-peak square wave signal. This is useful for probe compensation adjustment and a general check of oscilloscope calibration accuracy.

18. ⏚ **Jack.** Oscilloscope chassis ground, and earth ground via three-wire ac power cord.

HORIZONTAL CONTROLS

SWEEP CONTROLS

19. **Sweep TIME/DIV Control.** Provides step selection of sweep rate. When the **VAR SWEEP** control is set to **CAL**, sweep rate is calibrated. This control has 18 steps from 0.5 µs/div to 0.2 s/div, in a 1-2-5 sequence.

20. **VAR SWEEP Control.** Rotation of control is vernier adjustment for sweep rate. In fully clockwise (**CAL**) position, sweep rate is calibrated.

21. **◂▸ X POSition, PULL X10 Control.**
    - **◂▸ X POSition:**
      Horizontal position control.
    - **PULL 10X MAG:**
      Selects ten times sweep magnification when pulled out, normal when pushed in. Increases maximum sweep rate to 50 ns/div.

22. **X-Y Switch.** When this switch is engaged, the **X-Y** mode of operation is selected. The channel 1 input becomes the Y-axis and the channel 2 input becomes the X-axis. The Trigger **SOURCE** and Trigger **COUPLING** controls are disabled when the **X-Y** switch is engaged. The **VERTICAL MODE** switches should all be disengaged when the **X-Y** mode of operation is selected.

TRIGGERING CONTROLS

23. **Trigger SOURCE Switch.** Selects source of sweep trigger. Four position lever switch with the following positions:
    - **CH 1:**
      The channel 1 input signal becomes the sweep trigger, regardless of the **VERTICAL MODE** switch setting.
    - **CH 2:**
      Channel 2 signal becomes sweep trigger, regardless of **VERTICAL MODE** switch setting.
    - **ALT:**
      The trigger source follows the **VERTICAL MODE** switch setting for single trace operation (for dual trace operation, the triggering source alternates between channel 1 and channel 2). This mode permits each waveform viewed to become its own trigger signal. For dual-trace, triggering is impossible unless input signals (with sufficient triggering level) are applied to both input jacks. Triggering is also impossible when the **CHOP** dual-trace operation is selected.
    - **EXT:**
      Signal from **EXT TRIG** jack becomes sweep trigger.

24. **Trigger COUPLING Switch.** Selects trigger coupling. Four-position lever switch with the following positions:
    - **AC:**
      Trigger is capacitively coupled; dc component is blocked.

TV H:
Used for triggering from horizontal sync pulses.

TV V:
Used for triggering from vertical sync pulses.

LINE:
Signal derived from input line voltage (50/60 Hz) becomes trigger.

25. **TRIG LEVEL/PUSH AUTO Control.**

TRIG LEVEL Control:
Trigger level adjustment, determines the point on the triggering waveform where the sweep is triggered. Rotation in the (-) direction (counterclockwise) selects more negative point of triggering, and rotation in the (+) direction (clockwise) selects more positive point of triggering.

PUSH AUTO Control:
When pushed in, automatic triggering is selected. In automatic triggering mode, sweep is generated in absence of adequate trigger signal; automatically reverts to triggered sweep operation when adequate trigger signal is present. When pulled out, normal triggering is selected. In normal triggering mode, sweep is only generated when adequate trigger signal is present.

26. **SLOPE Switch.** When switch is disengaged, positive going (+) slope is selectedas trigger. When switch is engaged, negative (-) going slope is selected as trigger.

27. **EXT TRIG Jack.** External trigger input for single and dual-trace operation.

REAR PANEL CONTROLS

28. **CH 1 OUT Jack.** Output terminal where sample of channel 1 signal is available. Amplitude of output is 50 millivolts per division of vertical deflection seen on CRT when terminated into 50 ohms. Output impedance is 50 ohms.

29. **Power Cord Receptacle.**

30. **Fuse Holder/Line Voltage Selector.** Contains fuse and selects line voltage.

31. **Tilt Stand.** (Not Shown).

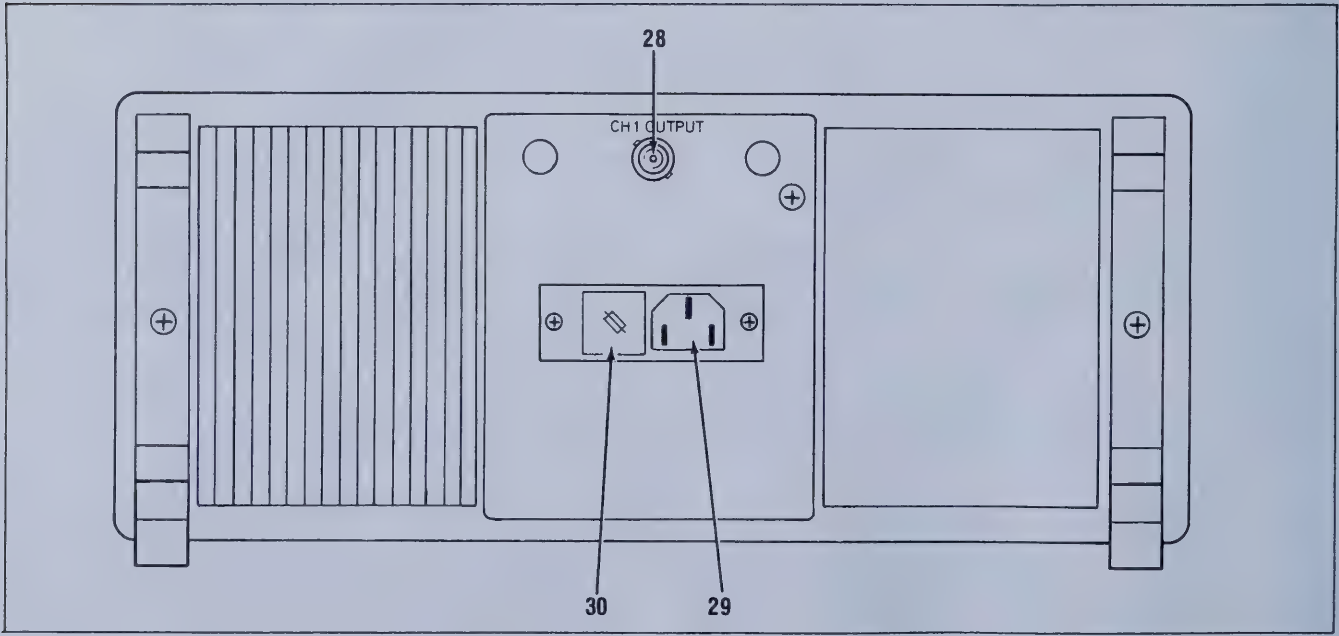


Fig. 2. Rear Panel Controls.

OPERATING INSTRUCTIONS

SAFETY PRECAUTIONS

WARNING

The following precautions must be observed to help prevent electric shock.

1. When the oscilloscope is used to make measurements in equipment that contains high voltage, there is always a certain amount of danger from electrical shock. The person using the oscilloscope in such conditions should be a qualified electronics technician or otherwise trained and qualified to work in such circumstances. Observe the TEST INSTRUMENT SAFETY recommendations listed on the inside front cover of this manual.

2. Do not operate this oscilloscope with the case removed unless you are a qualified service technician. High voltage up to 2,000 volts is present when the unit is operating with the case removed.

3. The ground wire of the 3-wire ac power plug places the chassis and housing of the oscilloscope at earth ground. Use only a 3-wire outlet, and do not attempt to defeat the ground wire connection or float the oscilloscope; to do so may pose a great safety hazard.

4. Special precautions are required to measure or observe line voltage waveforms with any oscilloscope. Use the following procedure:

   a. Do not connect the ground clip of the probe to either side of the line. The clip is already at earth ground and touching it to the hot side of the line may "weld" or "disintegrate" the probe tip and cause possible injury, plus possible damage to the scope or probe.

   b. Insert the probe tip into one side of the line voltage receptacle, then the other. One side of the receptacle should be "hot" and produce the waveform. The other side of the receptacle is the ac return and no waveform should result.

EQUIPMENT PROTECTION PRECAUTIONS

CAUTION

The following precautions will help avoid damage to the oscilloscope.

1. Never allow a small spot of high brilliance to remain stationary on the screen for more than a few seconds. The screen may become permanently burned. A spot will occur when the scope is set up for X-Y operation and no signal is applied. Either reduce the intensity so the spot is barely visible, apply signal, or switch back to normal sweep operation. It is also advisable to use low intensity with **AUTO** triggering and no signal applied for long periods. A high intensity trace at the same position could cause a line to become permanently burned onto the screen.

2. Do not obstruct the ventilating holes in the case, as this will increase the internal temperature.

3. Excessive voltage applied to the input jacks may damage the oscilloscope. The maximum ratings of the inputs are as follows:

   CH 1 and CH 2:
   400 V dc + ac peak.
   EXT TRIG:
   200 V dc + ac peak.

   Never apply external voltage to oscilloscope output jacks.

4. Always connect a cable from the ground terminal of the oscilloscope to the chassis of the equipment under test. Without this precaution, the entire current for the equipment under test may be drawn through the probe clip leads under certain circumstances. Such conditions could also pose a safety hazard, which the ground cable will prevent.

5. The probe ground clips are at oscilloscope and earth ground and should be connected only to the earth ground or isolated common of the equipment under test. To measure with respect to any point other than the common, use CH 2 - CH 1 subtract operation (**ADD** mode and **INV 1**), with the channel 2 probe to the point of measurement and the channel 1 probe to the point of reference. Use this method even if the reference point is a dc voltage with no signal.

OPERATING TIPS

The following recommendations will help obtain the best performance from the oscilloscope.

1. Always use the probe ground clips for best results, attached to a circuit ground point near the point of measurement. Do not rely solely on an external ground wire in lieu of the probe ground clips as undesired signals may be induced.

2. Avoid the following operating conditions:
   a. Direct sunlight.
   b. High temperature and humidity.
   c. Mechanical vibration.
   d. Electrical noise and strong magnetic fields, such as near large motors, power supplies, transformers, etc.

3. Occasionally check trace rotation, probe compensation, and calibration accuracy of the oscilloscope using the procedures found in the MAINTENANCE section of this manual.

4. Terminate the output of a signal generator in its characteristic impedance to minimize ringing, especially if the signal has fast edges such as square waves or pulses. For example, the typical 50 Ω output of a square wave generator should be terminated into an external 50 Ω terminating resistor and connected to the oscilloscope with 50 Ω coaxial cable.

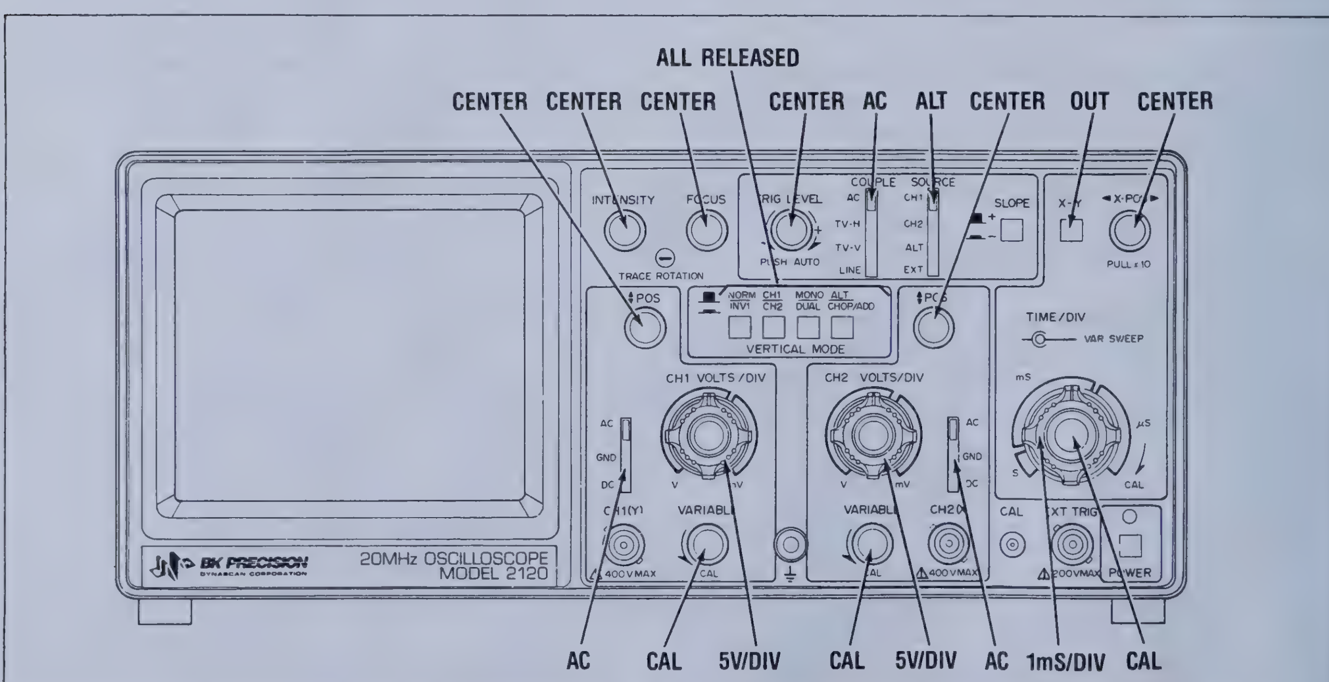


Fig. 3. Initial Control Settings.

5. Probe compensation adjustment matches the probe to the input of the scope. For best results, compensation should be adjusted initially, then the same probe always used with the same channel. Probe compensation should be readjusted when a probe from a different oscilloscope is used.

INITIAL STARTING PROCEDURE

Until you familiarize yourself with the use of all controls, the settings shown in Fig. 3 may be used as a reference point to obtain a trace on the CRT in preparation for waveform observation.

1. Press the **POWER** switch; the unit will be turned on and the pilot light will be illuminated.

2. The **CH 1/CH 2** switch should be set to **CH 1** (disengaged) and the **TRIG LEVEL** control should be set to **AUTO** (pushed in).

3. A trace should appear on the CRT. Adjust the trace brightness with the **INTENSITY** control, and the trace sharpness with the **FOCUS** control.

SINGLE TRACE DISPLAY

Either channel 1 or channel 2 may be used for single-trace operation. The advantage of using channel 1 is that the waveform on the display can be inverted if desired with the **INV 1** switch.

1. Perform the steps of the "Initial Starting Procedure" with the **CH 1/CH 2** switch set to **CH 1**.

2. Connect the probe to the **CH 1 (Y)** input jack.

3. Connect the probe ground clip to the chassis or common of the equipment under test. Connect the probe tip to the point of measurement.

4. If no waveforms appear, increase the sensitivity by turning the **CH 1 VOLTS/DIV** control clockwise to a position that gives 2 to 6 divisions vertical deflection.

5. The display on the CRT may be unsynchronized. Refer to the "Triggering" paragraphs in this section for procedures on setting triggering and sweep time controls to obtain a stable display showing the desired number of waveforms.

DUAL TRACE DISPLAY

In observing simultaneous waveforms on channel 1 and 2, the waveforms are usually related in frequency, or one of the waveforms is synchronized to the other, although the basic frequencies are different. If the two waveforms have no phase or frequency relationship, there is seldom reason to observe both waveforms simultaneously. However, when the trigger **SOURCE** switch is set to the **ALT** position, two waveforms not related in frequency or period can be simultaneously viewed.

1. Connect probes to both the **CH 1 (Y)** and **CH 2 (X)** input jacks.

2. Connect the ground clips of the probes to the chassis or common of the equipment under test. Connect the tips of the probes to the two points in the circuit where waveforms are to be measured.

3. When the **MONO/DUAL** switch is set to **MONO** and the **ALT/CHOP/ADD** switch is set to **ADD**, the algebraic sum of CH 1 + CH 2 is displayed as a single trace. When the **INV 1** switch is also engaged, the algebraic difference of CH 2 - CH 1 is displayed.

4. To view both waveforms simultaneously, set the **MONO/DUAL** switch to **DUAL** and select either **ALT** (alternate) or **CHOP** with the **ALT/CHOP/ADD** switch.

5. In the **ALT** mode, one sweep displays the channel 1 signal and the next sweep displays the channel 2 signal in an alternating sequence. Alternate sweep is normally used for viewing high-frequency or high-speed waveforms at sweep times of 1 ms/div and faster, but may be selected at any sweep time.

6. In the **CHOP** mode, the sweep is chopped and switched between channel 1 and channel 2. Chop sweep is normally used for low-frequency or low-speed waveforms at sweep times of 1 ms/div and slower.
   a. If chop sweep is used at sweep times of 0.2 ms/div and faster, the chop rate becomes a significant portion of the sweep and may become visible in the displayed waveform. However, you may select chop sweep at any sweep time for special applications. For example, the only way to observe simultaneous events on a dual-trace scope at any sweep rate is with chop sweep.
   b. Note that this oscilloscope is not intended to be used with the **CHOP** display mode and the **ALT** triggering source mode selected simultaneously. It may be impossible to synchronize the display with this combination. Use the **ALT** display mode instead or select a trigger **SOURCE** of **CH 1** or **CH 2**.

7. Adjust the channel 1 and 2 ⬍ **POSition** controls to place the channel 1 trace above the channel 2 trace.

8. Set the **CH 1** and **CH 2 VOLTS/DIV** controls to a position that gives 2 to 3 divisions of vertical deflection for each trace. If the display on the screen is unsynchronized, refer to the "Triggering" paragraphs in this section of the manual for procedures for setting triggering and sweep time controls to obtain a stable display showing the desired number of waveforms.

TRIGGERING

The Model 2120 Oscilloscope provides versatility in sync triggering for ability to obtain a stable, jitter-free display in single-trace, or dual-trace operation. The proper settings depend upon the type of waveforms being observed and the type of measurement desired. An explanation of the various controls which affect synchronization is given to help you select the proper setting over a wide range of conditions.

PUSH AUTO Switch

1. The pulled out position provides normal triggered sweep operation. The sweep remains at rest until the selected trigger source signal crosses the threshold level set by the **TRIG LEVEL** control. The trigger causes one sweep to be generated, after which the sweep again remains at rest until triggered. In the normal triggering mode, there will be no trace unless an adequate trigger signal is present. In the **ALT VERTICAL MODE** of dual trace operation with the **SOURCE** switch also set to **ALT**, there will be no trace unless both channel 1 and channel 2 signals are adequate for triggering. Typically, signals that produce even 1/2 division of vertical deflection are adequate for normal triggered sweep operation.

2. In the **AUTO** position (pushed in), automatic sweep operation is selected. In automatic sweep operation, the sweep generator free runs to generate a sweep without a trigger signal. However, it automatically switches to triggered sweep operation if an acceptable trigger source signal is present. The **AUTO** position is handy when first setting up the scope to observe a waveform; it provides sweep for waveform observation until other controls can be properly set. Once the controls are set, operation is often switched back to the normal triggering mode, since it is more sensitive. Automatic sweep must be used for dc measurements and signals of such low amplitude that they will not trigger the sweep.

Trigger SOURCE Switch

The trigger **SOURCE** switch (**CH 1, CH 2,** etc.) selects the signal to be used as the sync trigger.

1. If the **SOURCE** switch is set to **CH 1** (or **CH 2**) the channel 1 (or channel 2) signal becomes the trigger source regardless of the **VERTICAL MODE** selection. **CH 1,**

or **CH 2** are often used as the trigger source for phase or timing comparison measurements.

2. When the **ALT** position is selected, the trigger source is dependent upon the **VERTICAL MODE** selection. In this manner, each waveform being observed becomes its own trigger signal.
   a. When the vertical mode is changed from **CH 1** to **CH 2**, the trigger source is also changed from **CH 1** to **CH 2**, and vice versa. This is very convenient for single trace operation.
   b. When the **ALT** dual-trace **VERTICAL MODE** is selected, the trigger source alternates between **CH 1** and **CH 2** with each sweep. This is convenient for checking amplitudes, waveshape, or waveform period measurements, and even permits simultaneous observation of two waveforms which are not related in frequency or period. However, this setting is not suitable for phase or timing comparison measurements. For such measurements, both traces must be triggered by the same sync signal.
   c. When the **CHOP** dual-trace **VERTICAL MODE** is selected, synchronization of the display is not always possible. Use the **ALT** mode instead, or change the **SOURCE** switch setting to **CH 1**, or **CH 2**.
3. If the **SOURCE** switch is set to the **EXT** position, the signal applied to the **EXT TRIG** jack becomes the trigger source. This signal must have a timing relationship to the displayed waveforms for a synchronized display.

TRIG LEVEL and SLOPE Controls
(Refer to Fig. 4)

A sweep trigger is developed when the trigger source signal crosses a preset threshold level. Rotation of the **TRIG LEVEL** control varies the threshold level. In the + direction, the triggering threshold shifts to a more positive value, and in the - direction, the triggering threshold shifts to a more negative value. When the control is centered, the threshold level is set at the approximate average of the signal used as the triggering source. Proper adjustment of this control usually synchronizes the display.

The **TRIG LEVEL** control adjusts the start of the sweep to almost any desired point on a waveform. On sine wave signals, the phase at which sweep begins is variable. Note that if the **TRIG LEVEL** control is rotated toward its extreme + or - setting, no sweep will be developed in the normal trigger mode because the triggering threshold exceeds the peak amplitude of the sync signal.

When the **SLOPE** control is set to the + position (released), the sweep is developed from the trigger source waveform as it crosses a threshold level in a positive-going direction. When the **SLOPE** control is set to the - position (engaged), a sweep trigger is developed from the trigger source waveform as it crosses the threshold level in a negative-going direction.

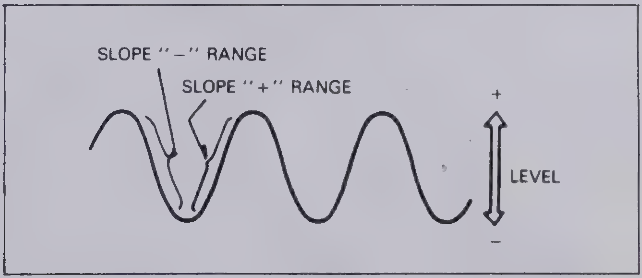


Fig. 4. Function of Slope and Level Controls.

Trigger COUPLING Switch

1. Use the **AC** position for viewing most types of waveforms. The trigger signal is capacitively coupled and may be used for all signals from 30 Hz to 20 MHz.
2. The **TV H** and **TV V** positions are primarily for viewing composite video waveforms. Horizontal sync pulses are selected as trigger when the trigger **COUPLING** switch is set to the **TV H** position, and vertical sync pulses are selected as trigger when the trigger **COUPLING** switch is set to the **TV V** position. The **TV H** and **TV V** positions may also be used as low frequency reject and high frequency reject coupling respec-

tively (with a cut off frequency of about 400 Hz). Additional procedures for observing video waveforms are given later in this section of the manual.

3. If the **COUPLING** switch is set to the **LINE** position, triggering is derived from the input line voltage (50/60 Hz) and the trigger **SOURCE** switch is disabled. This is useful for measurements that are related to line frequency.

Sweep TIME/DIV Control

Set the sweep **TIME/DIV** control to display the desired number of cycles of the waveform. If there are too many cycles displayed for good resolution, switch to a faster sweep time. If only a line is displayed, try a slower sweep time. When the sweep time is faster than the waveform being observed, only part of it will be displayed, which may appear as a straight line for a square wave or pulse waveform.

MAGNIFIED SWEEP OPERATION

Since merely shortening the sweep time to magnify a portion of an observed waveform can result in the desired portion disappearing off the screen, such magnified display should be performed using magnified sweep.

Using the ◂▸ **X POS**ition control, adjust the desired portion of waveform to the center of the CRT. Pull out the **PULL X10** knob to magnify the display ten times. For this type of display the sweep time is the sweep **TIME/DIV** setting divided by 10. Rotation of the ◂▸ **X POS**ition control can then be used to select the desired portion of the waveforms.

X-Y OPERATION

X-Y operation permits the oscilloscope to perform many measurements not possible with conventional sweep operation. The CRT display becomes an electronic graph of two instantaneous voltages. The display may be a direct comparison of the two voltages such as stereoscope display of stereo signal outputs. However, the **X-Y** mode can be used to graph almost any dynamic characteristic if a transducer is used to change the characteristic (frequency, temperature, velocity, etc.) into a voltage. One common application is frequency response measurements, where the Y axis corresponds to signal amplitude and the X axis corresponds to frequency.

1. Press the **X-Y** switch. In this mode, channel 1 becomes the Y axis input and channel 2 becomes the X axis input. All **VERTICAL MODE** switches should be disengaged for X-Y operation.

2. The X and Y positions are now adjusted using the ◂▸ **X POS**ition and the channel 1 ▴▾ **POS**ition controls respectively.

3. Adjust the amount of vertical (Y axis) deflection with the **CH 1 VOLTS/DIV** and **VARIABLE** controls.

4. Adjust the amount of horizontal (X axis) deflection with the **CH 2 VOLTS/DIV** and **VARIABLE** controls.

VIDEO SIGNAL OBSERVATION

Setting the **COUPLING** switch to the **TV H** or **TV V** position permits selection of horizontal or vertical sync pulses for sweep triggering when viewing composite video waveforms.

When the **TV H** mode is selected, horizontal sync pulses are selected as triggers to permit viewing of horizontal lines of video. A sweep time of about 10 µs/div is appropriate for displaying lines of video. The **VAR SWEEP** control can be set to display the exact number of waveforms desired.

When the **TV V** mode is selected, vertical sync pulses are selected as triggers to permit viewing of vertical fields and frames of video. A sweep time of 2 ms/div is appropriate for viewing fields of video and 5 ms/div for complete frames (two interlaced fields) of video.

At most points of measurement, a composite video signal is of the (-) polarity, that is, the sync pulses are negative and the video is positive. In this case, use **(-) SLOPE.** If the waveform is taken at a circuit point where the video waveform is inverted, the sync pulses are positive and the video is negative. In this case, use **(+) SLOPE.**

APPLICATIONS

DC VOLTAGE MEASUREMENTS
(Refer to Fig. 5)

The following technique may be used to measure the instantaneous dc level at any portion of a waveform, or to measure a dc voltage where no waveform is present.

1. Connect the signal to be measured to the input jack and set the **CH 1/CH 2** switch to the channel to be used. Set the **VOLTS/DIV** and sweep **TIME/DIV** controls to obtain a normal display of the waveform to be measured. The **VARIABLE** control must be set to **CAL.**

2. Set the **PUSH AUTO** switch to **AUTO** and the **AC-GND-DC** switch to **GND.** This establishes a trace at the zero volt reference. Using the ▲▼ **POSition** control, adjust the trace to the desired reference level position, making sure not to disturb this setting once made.

3. Set the **AC-GND-DC** switch to **DC** to observe the waveform, including its dc component. If an inappropriate reference level position was selected in step 2 or an inappropriate **VOLTS/DIV** setting was made, the waveform may not be visible at this point (deflected completely off the screen). This is especially true when the dc component is large with respect to the waveform amplitude. If so, reset the **VOLTS/DIV** control and repeat steps 2 and 3 until the waveform and the zero reference are both on the screen.

4. Use the ◀▶ **X POSition** control to bring the portion of the waveform to be measured to the center vertical graduation line of the graticule scale.

5. Measure the vertical distance from the zero reference level to the point to be measured (at least 3 divisions desirable for best accuracy). The reference level can be rechecked by momentarily returning the **AC-GND-DC** switch to **GND.**

6. Multiply the distance measured above by the **VOLTS/DIV** setting and the probe attenuation ratio as well. Voltages above the reference level are positive and voltages below the reference level are negative.

The measurement is summarized by the following equation:

DC level = Vert div x **VOLTS/DIV** x Probe

For the example shown in Fig. 5, the point being measured is 3.8 divisions from the reference level (ground potential). If the **VOLTS/DIV** control is set to 0.2 V and a 10:1 probe is used, the dc voltage level is calculated as follows:

$$\text{DC level} = 3.8\ (\text{div}) \times 0.2\ (\text{V/div}) \times 10$$
$$= 7.6\ \text{V}$$

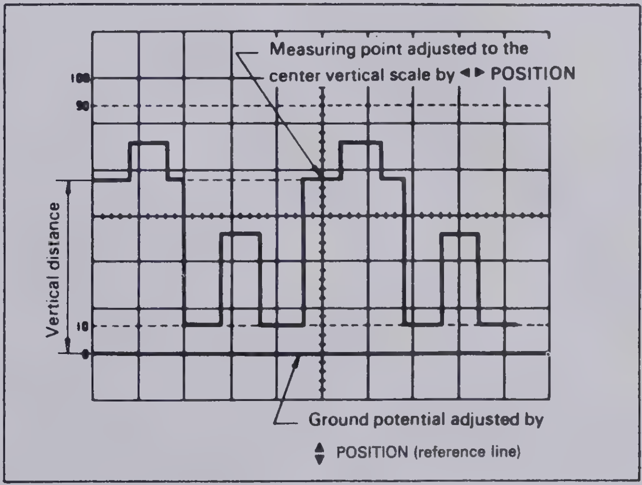


Fig. 5. DC Voltage Measurement.

MEASUREMENTS OF VOLTAGE BETWEEN TWO POINTS ON A WAVEFORM
(Refer to Fig. 6)

This procedure may be used to measure peak-to-peak voltages, or for measuring the

voltage difference between any two points on a waveform.

1. Connect the signal to be measured to the input connector, set the **CH 1/CH 2** switch to the channel to be used, and set the **AC-GND-DC** switch to **AC.** Set the **VOLTS/DIV** and sweep **TIME/DIV** controls to obtain a normal display of the waveform to be measured. The **VARIABLE** control must be set to **CAL.**

2. Using the ▲▼ **POS**ition control, adjust the waveform position such that one of the two points falls on a major horizontal graduation line.

3. Using the ◄► **X POS**ition control, adjust the second point to coincide with the center vertical graduation line.

4. Measure the vertical distance between the two points (at least 3 divisions desirable for best accuracy). Multiply the number of divisions by the setting of the **VOLTS/DIV** control. If a probe is used, further multiply this by the probe attenuation ratio.

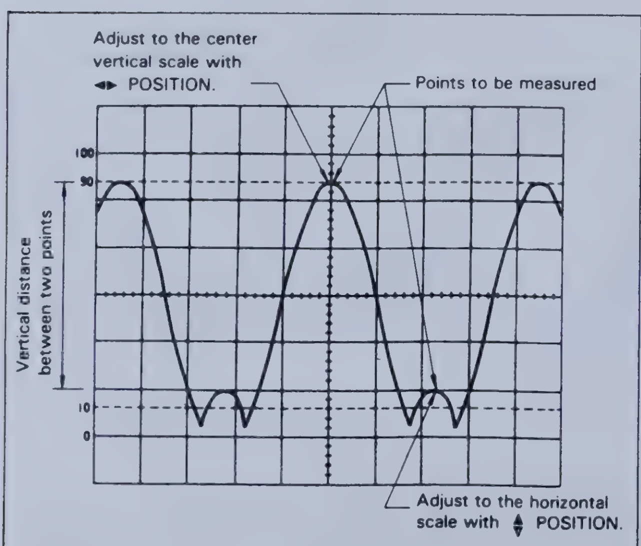


Fig. 6. Voltage Measurement.

The measurement is summarized by the following equation:

Voltage = Vert div x **VOLTS/DIV** x probe

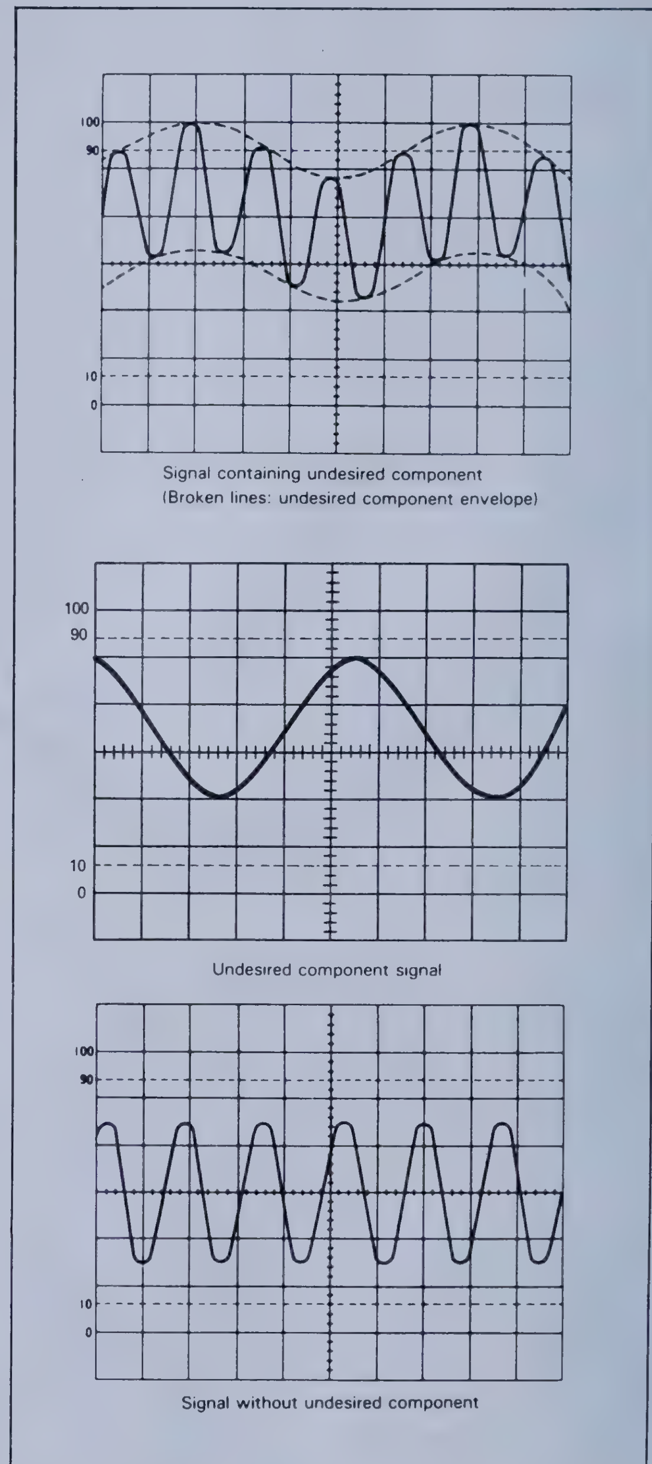


Fig. 7. Eliminating An Undesired Signal Component.

For the example shown in Fig. 6, the two points are separated by 4.4 divisions vertically. If the **VOLTS/DIV** setting is 20 mV and

a 10:1 probe is used, the voltage is calculated as follows:

Voltage = 4.4 (div) x 20 (mV/div) x 10

= 880 mV

ELIMINATION OF AN UNDESIRED SIGNAL COMPONENT
(Refer to Fig. 7)

The **ADD** mode can be conveniently used to cancel out the effect of an undesired signal component which is superimposed on the signal you wish to observe (for example, undesired 60 Hz hum superimposed on an rf signal).

1. Apply the signal containing an undesired component to the **CH 2 (X)** input jack and the undesired signal itself alone to the **CH 1 (Y)** input jack.

2. Select the **CHOP DUAL**-trace mode and set the trigger **SOURCE** switch to **CH 1.** Adjust the controls to display two signals, such as shown in Fig. 7. Verify that the channel 1 trace represents the unwanted signal in reverse polarity. The polarity may be reversed by engaging the **INV 1** switch.

3. Now set the **MONO/DUAL** switch to **MONO,** set the trigger **SOURCE** switch to **ALT,** and set the **ALT/CHOP/ ADD** switch to the **ADD** position. Adjust the **CH 1 VOLTS/DIV** and **VARIABLE** controls so that the undesired signal component is cancelled as much as possible. The remaining signal should be the signal you wish to observe alone, and free of the unwanted signal.

TIME MEASUREMENTS
(Refer to Fig. 8)

This is the procedure for making time (period) measurements between two points on a waveform. The two points may be the beginning and ending of one complete cycle if desired.

1. Connect the signal to be measured to the input connector and set the **CH 1/CH 2** switch to the channel to be used. Set the **VOLTS/DIV** and sweep **TIME/DIV** controls to obtain a normal display of the waveform to be measured. Be sure the **VAR SWEEP** control is set to **CAL.**

2. Using the ▲▼ **POSition** control, set one of the points to be used as a reference to coincide with the horizontal center line. Use the ◄► **X POSition** control to set this point at the intersection of any vertical graduation line.

3. Measure the horizontal distance between the two points (at least 4 divisions desirable for best accuracy). Multiply this by the setting of the sweep **TIME/DIV** control to obtain the time between the two points. If **X10** magnification is used, multiply this further by 1/10.

The measurement is summarized by the following equation:

Time = Hor div x **TIME/DIV**

(x 1/10 if **X10** is used)

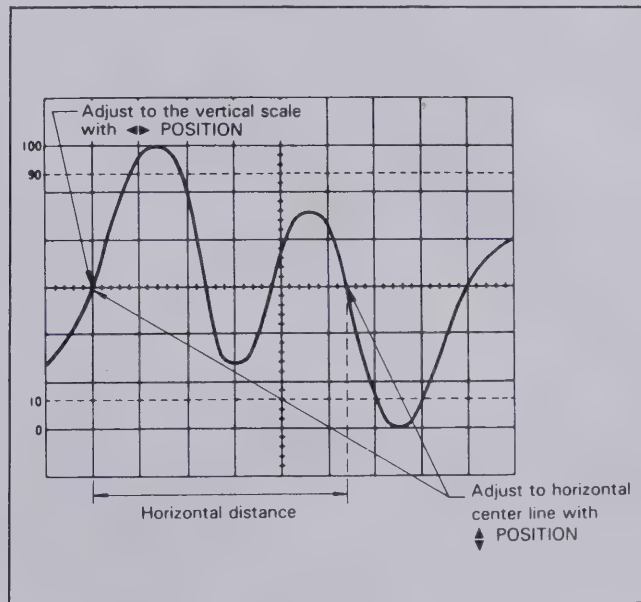


Fig. 8. Time Measurement.

For the example shown in Fig. 8, the horizontal distance between the two points is 5.4 divisions. If the **TIME/DIV** is 0.2 ms and **X10** magnification is not used, the time period is calculated as follows:

$$\text{Time} = 5.4 \text{ (div)} \times 0.2 \text{ (ms/div)}$$

$$= 1.08 \text{ ms}$$

FREQUENCY MEASUREMENTS

Method No. 1
(Refer to Fig. 9)

Frequency measurements are made by measuring the time period of one cycle of waveform and calculating the frequency, which equals the reciprocal of the time period.

1. Set up the oscilloscope to display one cycle of waveform (see Fig. 9).

2. Measure the time period of one cycle and calculate the frequency as follows:

$$\text{Freq} = \frac{1}{\text{Period}}$$

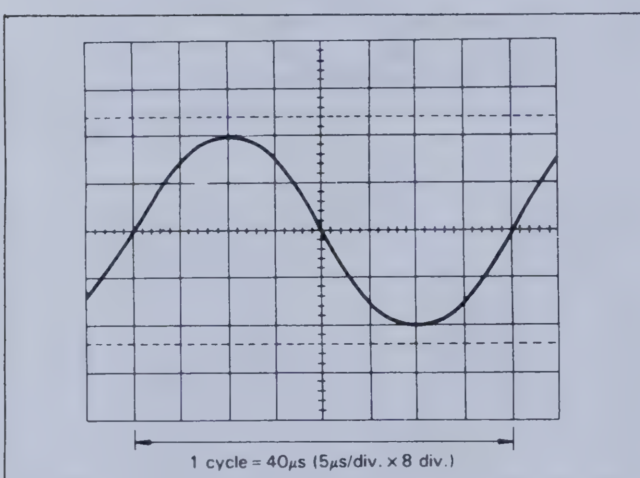


Fig. 9. Frequency Measurement.

In the example shown in Fig. 9, a period of 40 μs is observed. Substituting this value into the above equation, the frequency is calculated as follows:

$$\text{Freq} = \frac{1}{40 \times 10^{-6}}$$

$$= 2.5 \times 10^4$$

$$= 25 \text{ kHz}$$

Method No. 2
(Refer to Fig. 10)

While the previously described method relies upon direct period measurement of one cycle, the frequency may also be measured by counting the number of cycles present in a given time period.

1. Set up the oscilloscope to display several cycles of the waveform. The **VAR SWEEP** control must be set to **CAL.**

2. Count the number of cycles of waveform between a chosen set of vertical graduation lines (see Fig. 10).

3. Multiply the number of horizontal divisions by the sweep **TIME/DIV** setting to calculate the time span. Multiply the reciprocal of this value by the number of cycles present in the time span. If **X10** magnification is used, multiply this further by 10. Note that errors will occur for displays having only a few cycles.

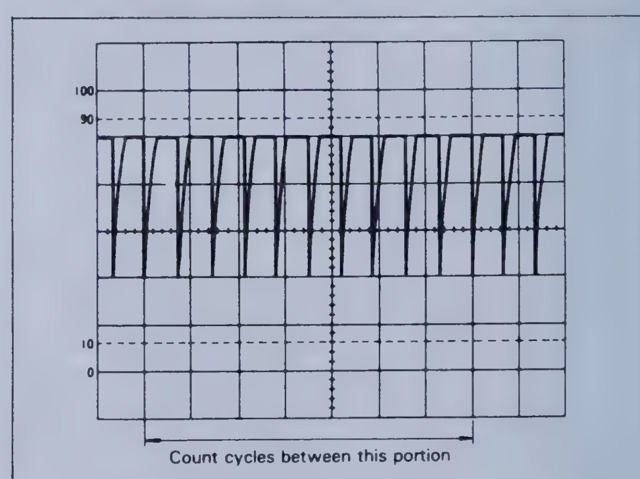


Fig. 10. Alternate Method of Frequency Measurement.

The measurement is summarized by the following equation:

$$\text{Freq} = \frac{\text{No of cycles (x 10 for } \textbf{X10}\text{)}}{\text{Hor div} \times \textbf{TIME/DIV}}$$

For the example shown in Fig. 13, there are 10 cycles within 7 divisions. If the sweep

TIME/DIV is 5 µs and **X10** magnification is not used, the frequency is calculated as follows:

$$\text{Freq} = \frac{10\ (\text{cycles})}{7\ (\text{div})\ \times\ 5\ (\mu s)} = 285.7\ \text{kHz}$$

PULSE WIDTH MEASUREMENTS
(Refer to Fig. 11)

1. Apply the pulse signal to the input jack and set the **CH 1/CH 2** switch to the channel to be used.

2. Use the **VOLTS/DIV** and **VARIABLE** controls to adjust the display so the waveform is easily observed. Use the ▲▼ **POS**ition control to position the pulse over the center horizontal graduation line. Use the ◄► **X POS**ition control to align the leading edge of the pulse with one of the vertical graduation lines.

3. Measure the distance between the leading edge and trailing edge of the pulse (along the center horizontal graduation line). Be sure that the **VAR SWEEP** control is set to **CAL.** Multiply the number of horizontal divisions by the sweep **TIME/DIV**, and if **X10** magnification is used, further multiply this value by 1/10.

The measurement is summarized by the following equation:

Pulse Width = Hor div x **TIME/DIV**

(x 1/10 if **X10** is used)

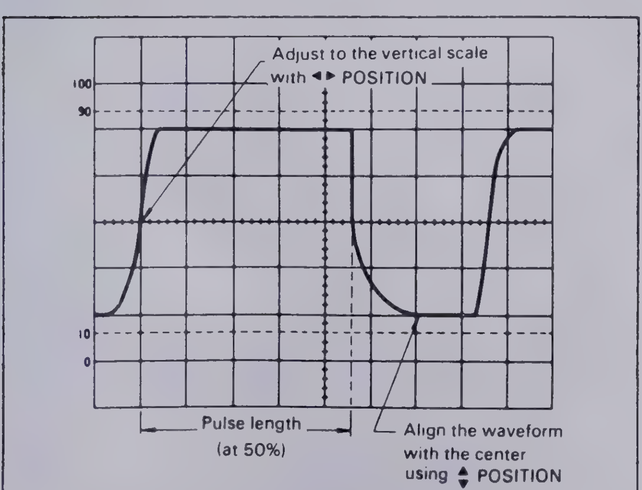


Fig. 11. Pulse Width Measurement.

For the example shown in Fig. 11, the pulse width at the center of the pulse is 4.6 divisions. If the sweep **TIME/DIV** is 0.2 ms and **X10** magnification is used, the pulse width is calculated as follows:

Pulse Width =

$$4.6\ (\text{div})\ \times\ 0.2\ (\text{ms/div})\ \times\ 1/10$$

$$= .092\ \text{ms or } 92\ \mu s$$

PULSE RISE TIME AND FALL TIME MEASUREMENTS

Method No. 1:
(Refer to Fig. 12)

For rise time and fall time measurements, the 10% and 90% amplitude points are used as starting and ending reference points.

1. Apply a signal to the input jack and set the **CH 1/CH 2** switch to the channel to be used. Use the **VOLTS/DIV** and **VARIABLE** controls to adjust the waveform peak to peak height to six divisions.

2. Using the ▲▼ **POS**ition control, adjust the display so that the waveform is centered vertically on the display. Set the sweep **TIME/DIV** control to as fast a setting as possible while still being able to observe both the 10% and 90% points. Set the **VAR SWEEP** control to the **CAL** position.

3. Use the ◄► **X POS**ition control to adjust the 10% point to coincide with a vertical graduation line and measure the horizontal distance in divisions between the 10% and 90% points on the waveform. Multiply this by the sweep **TIME/DIV** setting and also by 1/10 if the **X10** magnification mode was used.

NOTE
Be sure that the correct 10% and 90% lines are used. For such measurements the 0, 10, 90, and 100% points are marked on the CRT screen.

The measurement is summarized by the following equation:

$$\text{Rise Time} = \text{Hor div} \times \textbf{TIME/DIV}$$

(x 1/10 if **X10** is used)

For the example shown in Fig. 12, the horizontal distance is 4.0 divisions. The sweep **TIME/DIV** setting is 2 µs. The rise time is calculated as follows:

$$\text{Rise Time} = 4.0\ (\text{div}) \times 2\ (\mu s/\text{div}) = 8\ \mu s$$

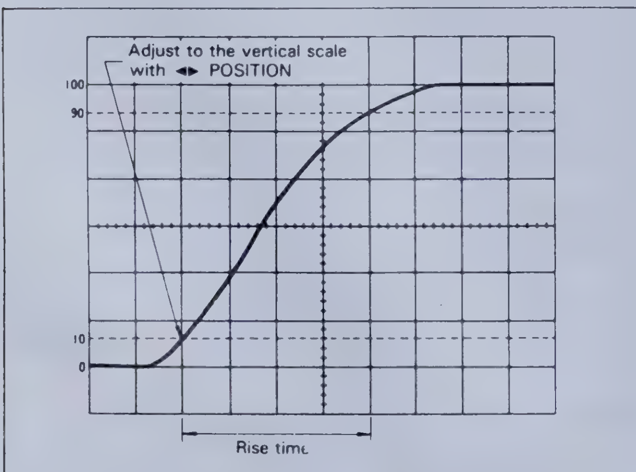


Fig. 12. Rise Time and Fall Time Measurement.

Method No. 2:
(Refer to Fig. 13)

The following step can be substituted for step 3 in method No. 1:

> Use the ◄►X **POS**ition control to set the 10% point to coincide with the center vertical graduation line and measure the horizontal distance to the point of the intersection of the waveform with the center horizontal line. Let this distance be D_1. Next, adjust the waveform position so that the 90% point coincides with the vertical centerline and measure the distance from that line to the intersection of the waveform with the horizontal centerline. Let this distance be D_2. The total horizontal distance is D_1 plus D_2.

The following equation summarizes the measurement:

$$\text{Rise Time} = (D_1 + D_2) \times \textbf{TIME/DIV}$$

(x 1/10 if **X10** is used)

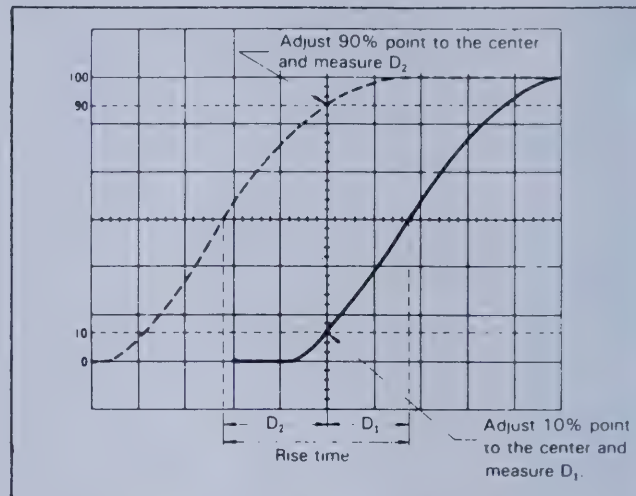


Fig. 13. Rise Time and Fall Time Measurement.

For the example shown in Fig. 13, D_1 is 1.8 divisions and D_2 is 2.2 divisions. If the sweep **TIME/DIV** setting is 2 µs, the rise time is calculated as follows:

$$\text{Rise Time} = (1.8 + 2.2) \times 2\ (\mu s/\text{div}) = 8\ \mu s$$

NOTE

See APPENDIX I for important rise time and fall time considerations.

TIME DIFFERENCE MEASUREMENTS
(Refer to Fig. 14)

This procedure is useful in measurement of time difference between signals that are synchronized to one another but skewed in time.

1. Apply the two signals to the **CH 1** and **CH 2** input jacks and select the dual-trace display mode (either the **CHOP** or **ALT** mode). **CHOP** is usually chosen for low frequency signals and **ALT** for high frequency signals.

2. Select the faster of the two signals as the trigger **SOURCE** and use the **VOLTS/DIV** and sweep **TIME/DIV** controls to obtain an easily observed display.

3. Use the ▲▼ **POS**ition controls to superimpose both waveforms to intersect the center horizontal graduation line as

shown in Fig. 14. Use the ◂▸ **X POS**ition control to set the reference signal coincident with one of the vertical graduation lines.

4. Measure the horizontal distance between the two signals and multiply this distance (in divisions) by the sweep **TIME/DIV** setting. If **X10** magnification is used, multiply this again by 1/10.

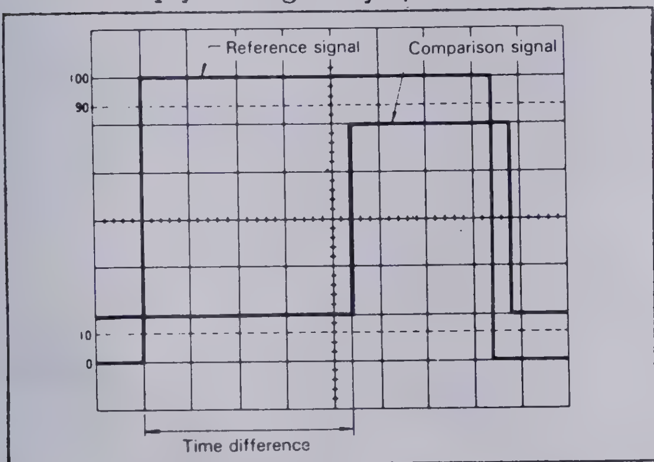


Fig. 14. Time Difference Measurement.

The measurement is summarized by the following equation:

Time = Hor div x **TIME/DIV**

(x 1/10 if **X10** is used)

For the example shown in Fig. 14, the horizontal distance measured is 4.4 divisions. If the sweep **TIME/DIV** is 0.2 ms and **X10** magnification is not used, the time difference is calculated as follows:

Time = 4.4 (div) x 0.2 (ms/div)

= 0.88 ms or 880 μs

PHASE DIFFERENCE MEASUREMENTS

Method No. 1
(Refer to Fig. 15)

This procedure is useful in measuring the phase difference of signals of the same frequency.

1. Apply the two signals to the **CH 1** and **CH 2** input jacks, selecting the dual-trace display mode (either **ALT** or **CHOP**).

2. Set the trigger **SOURCE** switch to the signal which is leading in phase (or to **LINE** if device is line voltage operated) and use the **VOLTS/DIV** controls to adjust the two waveforms so they are equal in amplitude.

3. Use the ▴▾ **POS**ition controls to position the waveforms in the vertical center of the screen. Use the **TIME/DIV** and **VAR SWEEP** controls to adjust the display so one cycle of the reference signal occupies 8 divisions horizontally (see Fig. 15). The **TRIG LEVEL** and ◂▸ **X POS**ition controls are also useful in achieving this display. The display should be as shown in Fig. 15, where one division now represents 45° in phase.

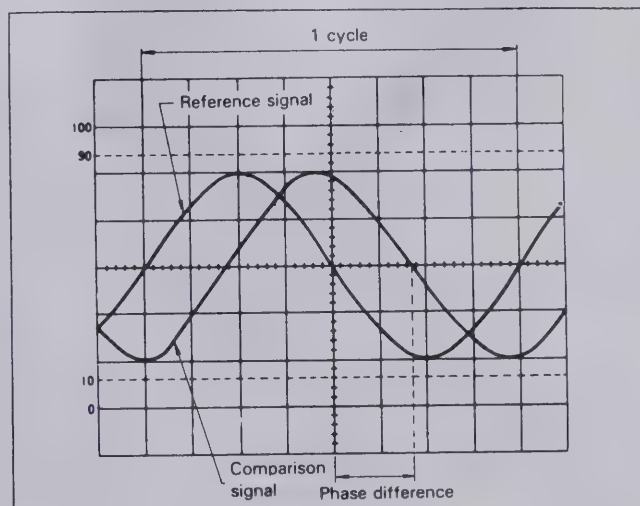


Fig. 15. Phase Difference Measurement.

4. Measure the horizontal distance between corresponding points on the two waveforms. Multiply the distance (in divisions) times 45° per division to obtain the phase difference.

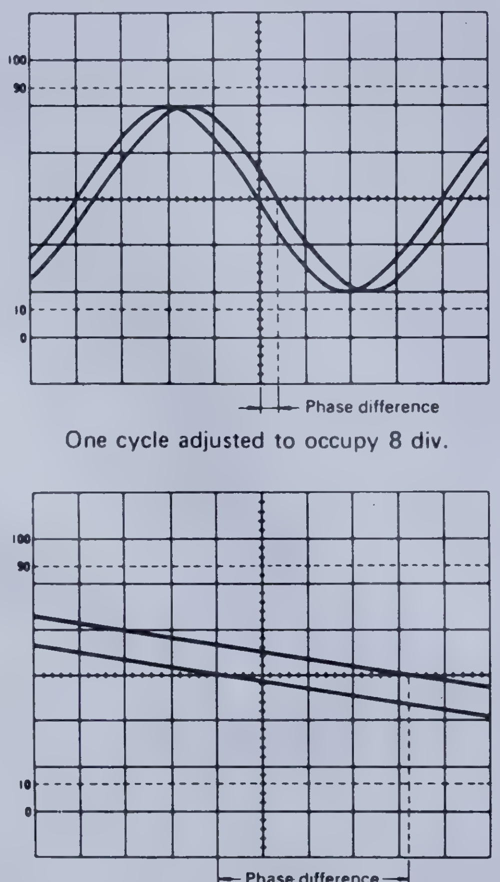
The measurement is summarized by the following equation:

Phase difference = Hor div x 45°/div

For the example shown in Fig. 15, the horizontal distance is 1.7 divisions. Thus, the phase difference is calculated as follows:

Phase difference = 1.7 x 45°/div = 76.5°

Method No. 2
(Refer to Fig. 16)



One cycle adjusted to occupy 8 div.

Expanded sweep waveform display.

Fig. 16. Measuring Small Phase Difference.

The above procedure allows 45° per division, which may not give the desired accuracy for small phase differences.

If greater accuracy is required, the sweep **TIME/DIV** setting may be changed to expand the display as shown in Fig. 16, but the **VAR SWEEP** setting must not be touched. If necessary, the **TRIG LEVEL** may be readjusted. For this type of operation, the relationship of one division to 45° no longer holds. Instead the following equation must be used:

$$\text{Phase diff} = \text{Hor div} \times 45^{\circ}/\text{div} \times \frac{A}{B}$$

Where:
A = New **TIME/DIV** setting.
B = Original **TIME/DIV** setting.

A simpler method of obtaining more accuracy quickly is to simply use **X10** magnification for a scale factor of 4.5°/division.

RELATIVE MEASUREMENTS

If the amplitude and period of some reference signal are known, an unknown signal may be measured for amplitude and period without the **VARIABLE** and **VAR SWEEP** controls set to **CAL.** The measurement is made in units relative to the reference signal.

Relative Voltage Measurements
(refer to Fig. 17)

1. Apply the reference signal to the input jack and adjust the display for a normal waveform display. Adjust the **VOLTS/DIV** and **VARIABLE** controls so that the amplitude of the reference signal occupies a fixed number of divisions. After adjusting, be sure not to disturb the setting of the **VARIABLE** control.

2. Calculate the vertical calibration coefficient as follows:

$$\text{vertical coefficient} = \frac{C}{D \times E}$$

Where:
C = Amplitude of reference signal (in volts).
D = Amplitude of reference signal (in divisions).
E = **VOLTS/DIV** setting.

3. Remove the reference signal and apply the unknown signal to the input jack, using only the **VOLTS/DIV** control to adjust the amplitude for easy observation (do not disturb the **VARIABLE** setting).

4. Measure the amplitude of the displayed waveform, in divisions. Multiply the number of divisions by the **VOLTS/DIV** setting and the vertical coefficient from

above to find the value of the unknown voltage.

The measurement is summarized by the following equation:

Unknown Voltage = Vert div x **VOLTS/DIV** x vert coefficient

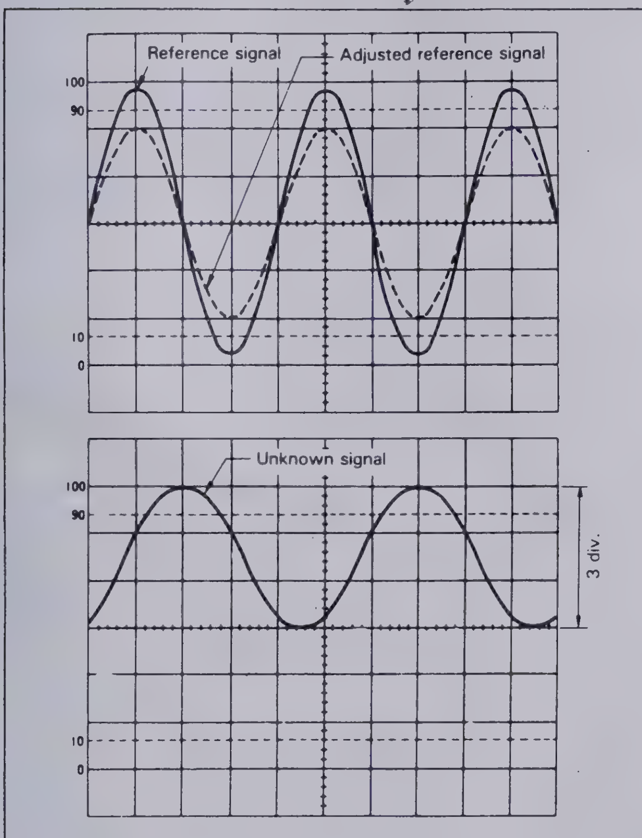


Fig. 17. Voltage Measurement, Relative Method.

For the example shown in Fig. 17, the **VARIABLE** control is adjusted so the amplitude of the reference signal is 4 divisions. If the reference signal is 2.0 V p-p, and the **VOLTS/DIV** setting is 1 V, the vertical coefficient is 0.5; which was calculated as follows:

$$\text{vertical coefficient} = \frac{2\ (\text{V})}{4\ (\text{div})\ \times\ 1\ (\text{V/div})} = 0.5$$

For the example shown in Fig. 17, the amplitude of the unknown signal is 3 divisions, and the previously calculated vertical coefficient is 0.5. If the **VOLTS/DIV** setting is 5 V, the unknown signal is 7.5 V p-p; which was calculated as follows:

$$\text{Unknown Voltage} = 3\ (\text{div})\ \times\ 5\ (\text{V/div})\ \times\ 0.5\ (\text{vert coef}) = 7.5\ \text{V}$$

NOTE

It is preferable that the reference voltage be the peak-to-peak value, as in the previous example. The measurement holds true for all waveforms if a p-p reference is used. It is also possible to use an rms value for the reference voltage. The unknown voltage value will also be in rms, but the measurement holds true only if both the reference and unknown signals are undistorted sine waves.

Relative Period Measurements
(refer to Fig. 18)

1. Apply the reference signal to the input jack and adjust the display for a normal waveform display. Using the sweep **TIME/DIV** and **VAR SWEEP** controls, adjust one cycle of the reference signal to occupy a fixed number of horizontal divisions. After this is done, be sure not to disturb the **VAR SWEEP** control setting

2. Calculate the sweep (horizontal) calibration coefficient using the following equation:

$$\text{Sweep coefficient} = \frac{F}{G \times H}$$

Where:
F = Period of reference signal (seconds).
G = Horizontal width of reference signal (divisions).
H = **TIME/DIV** setting.

3. Remove the reference signal and apply the unknown signal to the input jack,

using only the sweep **TIME/DIV** control to adjust the width of the display (do not disturb the **VAR SWEEP** setting).

4. Measure the width of one cycle of the displayed waveform, in divisions. Multiply the number of divisions by the sweep **TIME/DIV** setting and the sweep coefficient from above to find the period of the unknown waveform.

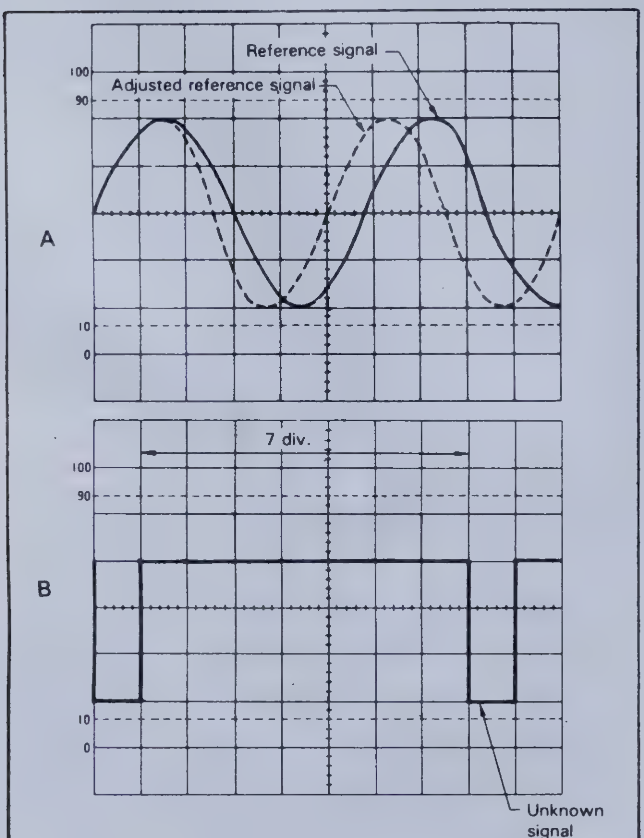


Fig. 18. Period Measurement, Relative Method.

The measurement is summarized by the following equation:

Unknown Period = Horizontal divisions x

TIME/DIV x sweep coefficient

For the example in Fig. 18A, the **VAR SWEEP** control is adjusted so the reference signal occupies 5 horizontal divisions. If the reference signal is 1.75 kHz, and the sweep **TIME/DIV** control is 0.1 ms, the sweep coefficient is calculated as follows:

$$\text{sweep coefficient} = \frac{1.75\ \text{kHz}^{-1}}{5\ (\text{div})\ \times\ 0.1\ (\text{ms/div})}$$

$$= 1.143$$

For the example in Fig. 18B, the width of the unknown signal is 7 divisions, and the previously calculated sweep coefficient is 1.143. If the sweep **TIME/DIV** setting is 0.2 ms, the period is calculated as follows:

Unknown Period =

7 (div) x 0.2 (ms/div) x 1.143 (sweep coef)

= 1.6 ms

X-Y MODE APPLICATIONS

Phase Measurements
(refer to Fig. 19)

A dual-trace method of phase measurement was previously described. A second method of phase measurement requires calculations based on the Lissajous patterns obtained using X-Y operation. Distortion due to non-linear amplification can also be displayed.

A sine wave is applied to the audio circuit being tested. The same sine wave is also applied to the vertical input of the oscilloscope, and the output of the tested circuit is applied to the horizontal input of the oscilloscope. The amount of phase difference between the two signals can be calculated from the resulting waveform.

1. Using an audio generator with a pure sinusoidal signal, apply a sine wave test signal at the desired test frequency to the audio network being tested.

2. Set the signal generator output for the normal operating level of the circuit being tested. If desired, the circuit's output may first be observed on the oscilloscope with normal sweep operation. If the test circuit is overdriven, the sine wave display on the oscilloscope is clipped and the signal level must be reduced.

3. Connect channel 1 to the input and channel 2 to the output of the test circuit. Set channel 1 and 2 gain controls for exactly the same amplitude waveform on the display in normal sweep operation.

4. Select X-Y operation by pressing the **X-Y** switch (all **VERTICAL MODE** switches should be released).

5. If necessary, repeat step 3, readjusting the channel 1 and 2 gain controls for a suitable viewing size. Some typical results are shown in Fig. 19.

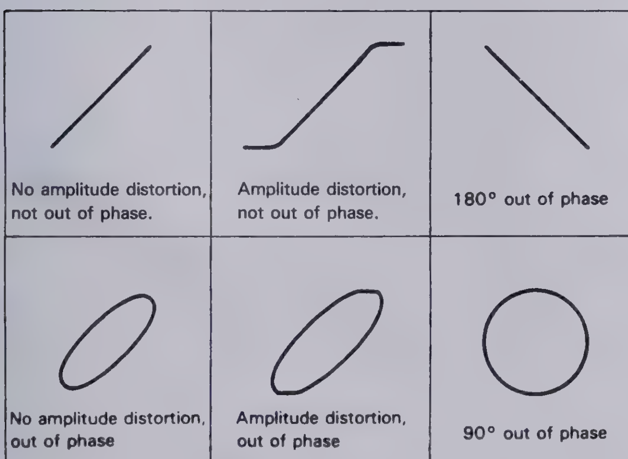


Fig. 19. Typical X-Y Phase Measurement Displays.

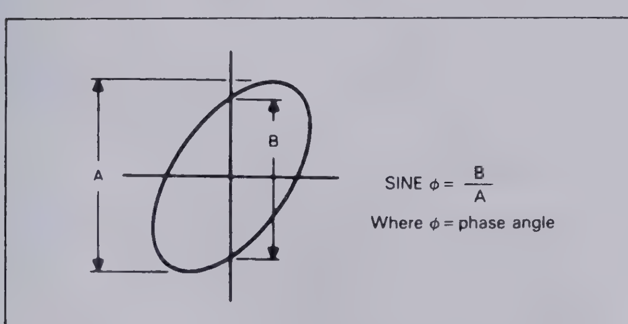


Fig. 20. Phase Measurement, X-Y Operation.

If the two signals are in phase, the oscilloscope trace is a straight diagonal line. If the vertical and horizontal gain are properly adjusted, this line is at a 45° angle. A 90° phase shift produces a circular oscilloscope pattern. Phase shift of less (or more) than 90° produces an elliptical oscilloscope pattern. The amount of phase shift can be calculated from the oscilloscope trace as shown in Fig. 20.

Frequency Response Measurements
(refer to Fig. 21)

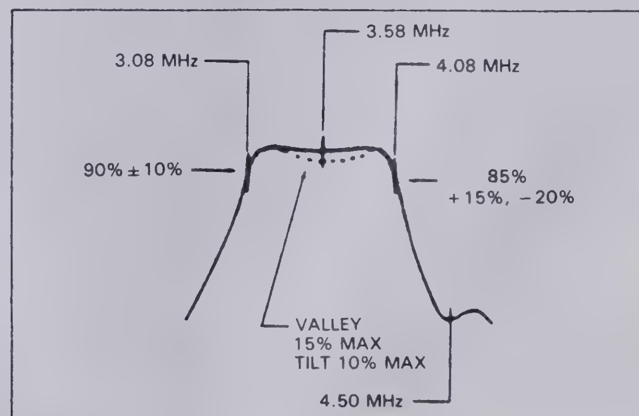


Fig. 21. Frequency Response Measurement.

A sweep generator and the X-Y mode of this oscilloscope may be used to measure the audio or rf frequency response of an active or passive device up to 20 MHz, such as an amplifier, band pass filter, coupling network, etc.

1. Connect the audio or rf output of the sweep generator to the input of the circuit under test and the output of the test circuit to channel 1 (vertical axis) of the oscilloscope. A demodulator probe will give a "text book" frequency response display as shown in Fig. 21, but a standard probe can be used which will result in an envelope display.

2. Connect the sweep ramp voltage of the sweep generator to the channel 2 input of the oscilloscope.

3. Set the **X-Y** switch to the **X-Y** position (engaged) and adjust the channel 1 and 2 controls for a suitable viewing size.

WARNING

The following instructions are for use by qualified service personnel only. To avoid electrical shock, do not perform any servicing other than contained in the operating instructions unless you are qualified to do so.

High voltage up to 2,000 volts is present when covers are removed and the unit is operating. Remember that high voltage may be retained indefinitely on high voltage capacitors. Also remember that ac line voltage is present on line voltage input circuits any time the instrument is plugged into an ac outlet, even if turned off. Unplug the oscilloscope and discharge high voltage capacitors before performing service procedures.

FUSE REPLACEMENT

If the fuse blows, the pilot light will go out and the oscilloscope will not operate. The fuse should not normally open unless a problem has developed in the unit. Try to determine and correct the cause of the blown fuse, then replace only with the correct value fuse. For 115 V line voltage operation, use a 630 mA, 250 V fuse. For 230 V line voltage operation, use a 315 mA, 250 V fuse. The fuse is located on the rear panel (see Fig. 6). Be sure that the fuse is installed so that the correct line voltage is selected (see LINE VOLTAGE SELECTION).

LINE VOLTAGE SELECTION

To select the desired line voltage, simply insert the fuse and fuse holder so that the appropriate voltage is at the top (pointed to by the arrow). Be sure to use the proper value fuse (see label on rear panel).

PERIODIC ADJUSTMENTS

Screwdriver adjustments only need to be checked and adjusted periodically. Probe compensation and trace rotation adjustments are included in this category. Procedures are given below.

Probe Compensation

1. Connect probes to **CH 1** and **CH 2** input jacks. Repeat procedure for each probe.
2. Touch tip of probe to **CAL** terminal.
3. Adjust oscilloscope controls to display 3 or 4 cycles of **CAL** square wave at 5 or 6 divisions amplitude.
4. Adjust compensation trimmer on probe for optimum square wave (minimum overshoot, rounding off, and tilt). Refer to Fig. 22.

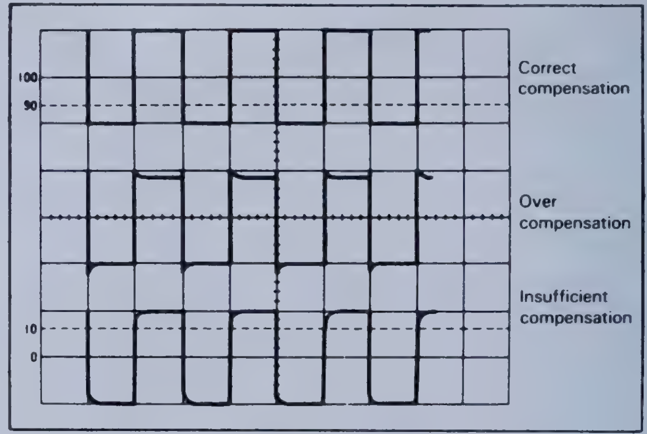


Fig. 22. Probe Compensation Adjustment.

Trace Rotation Adjustment

1. Set oscilloscope controls for a single trace display in **CH 1** mode, and with the channel 1 **AC-GND-DC** switch set to **GND.**
2. Use the channel 1 ⬍ **POSition** control to position the trace over the center horizontal line on the graticule scale. The trace should be exactly parallel with the horizontal line.
3. Use the **TRACE ROTATION** adjustment on the front panel to eliminate any trace tilt.

CALIBRATION CHECK

A general check of calibration accuracy may be made by displaying the output of the **CAL** terminal on the screen. This terminal provides a square wave of 0.2 V p-p. This signal should produce a displayed waveform amplitude of four divisions at 50 mV/div sensitivity for both channel 1 and 2 (with probes set for direct). With probes set for 10:1, there should be four divsions amplitude at 5 mV/div sensitivity. The **VARIABLE** controls must be set to **CAL** during this check.

The **CAL** signal may be used only as a general check of calibration accuracy, not as a signal source for performing recalibration adjustments; a signal source of ± 0.5% or better accuracy is required for calibration adjustments (the B & K-Precision Model 1400 Oscilloscope Calibrator is ideally suited for this).

INSTRUMENT REPAIR SERVICE

Because of the specialized skills and test equipment required for instrument repair and calibration, many customers prefer to rely upon **B & K-Precision** for this service. We maintain a network of **B & K-Precision** authorized service agencies for this purpose. To use this service, even if the oscilloscope is no longer under warranty, follow the instructions given in the WARRANTY SERVICE INSTRUCTION portion of this manual. There is a nominal charge for instruments out of warranty.

APPENDIX I

IMPORTANT CONSIDERATIONS FOR RISE TIME AND FALL TIME MEASUREMENTS

Error In Observed Measurement

The observed rise time (or fall time) as seen on the CRT is actually the cascaded rise time of the pulse being measured and the oscilloscope's own risetime. The two rise times are combined in square law addition as follows:

$$T_{observed} = \sqrt{(T_{pulse})^2 + (T_{scope})^2}$$

The effect of the oscilloscope's rise time is almost negligible when its rise time is at least 3 times as fast as that of the pulse being measured. Thus, slower rise times may be measured directly from the CRT. However, for faster rise time pulses, an error is introduced that increases progressively as the pulse rise time approaches that of the oscilloscope. Accurate measurements can still be obtained by calculation as described below.

Direct Measurements

The Model 2120 Oscilloscope has a rated rise time of 17.5 ns at all attenuator ranges. Thus, pulse rise times of about 53 ns or greater can be measured directly. Most rise times are measured at the fastest sweep speed and using **X10** magnification. For Model 2120, this sweep rate is 50 ns/div. A rise time measurement of less than about 1 division should be calculated.

Calculated Measurements

For observed rise times of less than 53 ns, the pulse rise time should be calculated to eliminate the error introduced by the cascaded oscilloscope rise time. Calculate pulse rise time as follows:

$$T_{pulse} = \sqrt{(T_{observed})^2 - (T_{scope})^2}$$

Limits Of Measurement

Measurements of pulse rise times that are faster than the oscilloscope's rated rise time are not recommended because a very small reading error introduces significant error into the calculation. This limit is reached when the "observed" rise time is about 1.3 times greater than the scope's rated rise time, about 23 ns.

Probe Considerations

For fast rise time measurements which approach the limits of measurement, direct connection via 50 Ω coaxial cable and 50 Ω termination is recommended where possible. When a probe is used, its rise time is also cascaded in square law addition. Thus the probe rating should be considerably faster than the oscilloscope if it is to be disregarded in the measurement.

WARRANTY SERVICE INSTRUCTIONS
(For U.S.A. and its Overseas Territories)

1. Refer to the MAINTENANCE section of your **B & K-Precision** instruction manual for adjustments that may be applicable.

2. If the above-mentioned does not correct the problem you are experiencing with your unit, pack it securely (preferably in the original carton or double-packed). Enclose a letter describing the problem and include your name and address. Deliver to, or ship PREPAID (UPS preferred in U.S.A.) to the nearest **B & K-Precision** authorized service agency (see list enclosed with unit).

If your list of authorized **B & K-Precision** service agencies has been misplaced, contact your distributor for the name of your nearest service agency, or write to:

B & K-Precision, Dynascan Corporation
Factory Service Operations
6460 West Cortland Street
Chicago, Illinois 60635
Tel (312) 889-8870
Telex: 25-3475

Also use this address for technical inquiries
and replacement parts orders.

LIMITED TWO-YEAR WARRANTY

DYNASCAN CORPORATION warrants to the original purchaser that its **B & K-Precision** product, and the component parts thereof, will be free from defects in workmanship and materials for a period of two years from the date of purchase.

DYNASCAN will, without charge, repair or replace, at its option, defective product or component parts upon delivery to an authorized **B & K-Precision** service contractor or the factory service department, accompanied by proof of the purchase date in the form of a sales receipt.

To obtain warranty coverage in the U.S.A., this product must be registered by completing and mailing the enclosed warranty registration card to DYNASCAN, **B & K-Precision,** 6460 West Cortland Street, Chicago, Illinois 60635 within fifteen (15) days from the date of purchase.

Exclusions: This warranty does not apply in the event of misuse or abuse of the product or as a result of unauthorized alterations or repairs. It is void if the serial number is altered, defaced or removed.

DYNASCAN shall not be liable for any consequential damages, including without limitation damages resulting from loss of use. Some states do not allow limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific rights and you may also have other rights which vary from state to state.

For your convenience we suggest you contact your **B & K-Precision** distributor, who may be authorized to make repairs or can refer you to the nearest service contractor. If warranty service cannot be obtained locally, please send the unit to **B & K-Precision** Service Department, 6460 West Cortland Street, Chicago, Illinois 60635, properly packaged to avoid damage in shipment.

B & K-Precision Test Instruments warrants products sold only in the U.S.A. and its overseas territories. In other countries, each distributor warrants the **B & K-Precision** products which it sells.

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